Burning behavior and external flames in a corridor-like enclosure using liquid pool fires

Burning Behaviour and External Flames in a Corridor-like Enclosure Using Liquid Pool Fires

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MOTIVATION

Spread of fire and smoke inside an enclosure and flames potentially emerging through openings could lead to extensive damage of buildings and in the worst case scenario loss of lives. Though typical living spaces are represented by rectangular enclosure geometries, there are supplementary constructions of different geometries. One of the most common is a corridor-like enclosure geometry representing tunnels, offices and various transportation means geometries such as aeroplanes, trains etc.

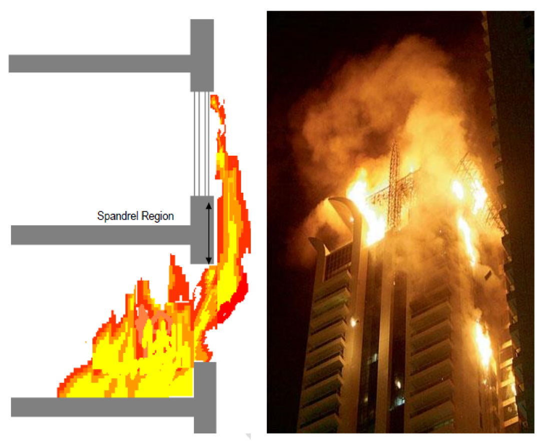

Figure 1. Fire spread inside an enclosure and flames emerging through the opening

SCOPE OF THIS STUDY

This work is an experimental investigation of the burning behaviour of ethanol pool fires in a corridor-like enclosure and subsequent façade flames emerging through the opening during steady-state burning period.

EXPERIMENTAL METHOD

Figure 2. Image of the experimental rig

Corridor-like enclosure
- 3 m long, constructed by six 0.5 m x 0.5 m cubic boxes
-Inner walls: 40 mm high temperature resistant board
- Outer walls: 12mm MDF board
- Façade: 1.8 m high x 1 m wide

Measurements
-Mass loss
-Heat release rate
-Temperature profiles inside
-Heat fluxes on the floor
-Heat fluxes on the façade
-Smoke production outside
-Combustion products outside
-Flame height using a camera

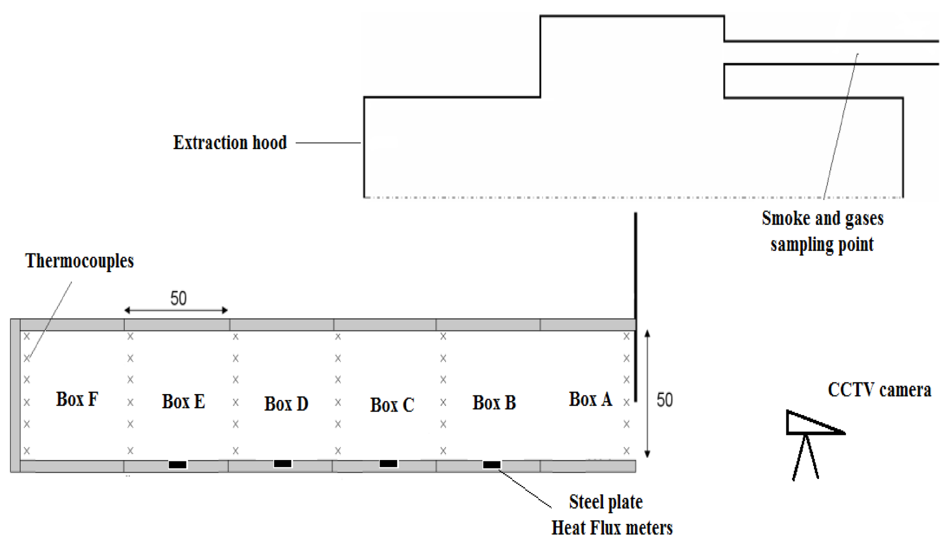

Figure 3. Layout of the experimental rig

PARAMETRIC STUDY

Parameters investigated
- ➢ ***Opening size***, using 8 opening sizes (Table 1)
- ➢ ***Pool fire size***, using circular water-cooled, St-St pans of two diameters 20 and 30 cm with constant level of fuel surface.
- ➢ ***Pool fire location***, by placing the pan inside either the Box A (front location) or the Box F (rear location)

W (cm)	10	15	10	20	25	30	50	50
H (cm)	10	15	25	20	25	30	25	50

Table 1. Opening sizes studied

In addition, free-burn experiments using the two pans were conducted for comparison reasons.

Pan Location	Pan Diameter	Opening
FRONT BOX (Box A)	20 cm	All 8 openings
	30 cm	All 8 openings
REAR BOX (Box F)	20 cm	All 8 openings
	30 cm	All 8 openings
Free-burn	20 cm	N.A.
	30 cm	

Table 2. Summary of the parameters studied

RESULTS

➢ **Free-burn cases**

The steady-burning period is considered for calculating the average burning rate.

Theoretical HRR: $Q_{theor} = \dot{m}_T \times \Delta H_c$ (kW)

Combustion efficiency: $\eta = Q_{act} / Q_{theor}$

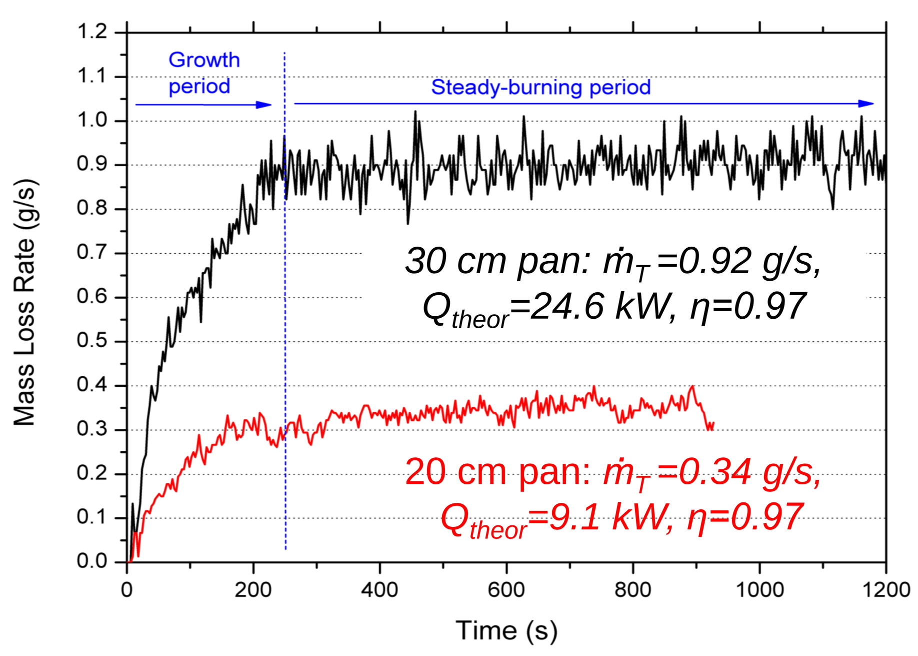

Figure 4. Free-burn burning rate for the two pans

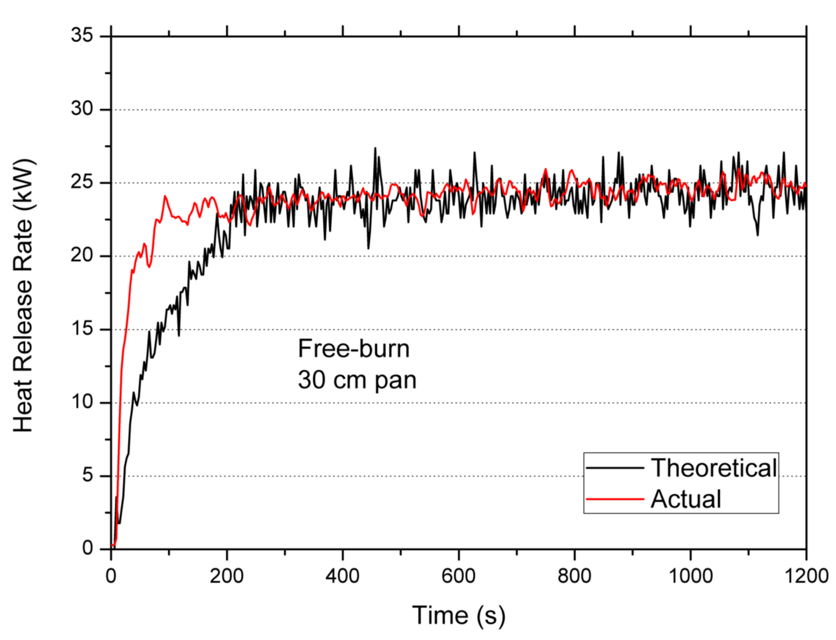

Figure 5. Theoretical HRR versus actual HRR measured on the hood for the 30 cm pan

➢ **Opening size influencing the burning behaviour**

The influence of the opening size is depicted in Fig. 6, showing the mass pyrolysis rate ($\dot{m}_T$) against the ventilation factor ($AH^{1/2}$ where A and H are the area and height of the opening respectively), both normalized by the fuel surface area (A_F).

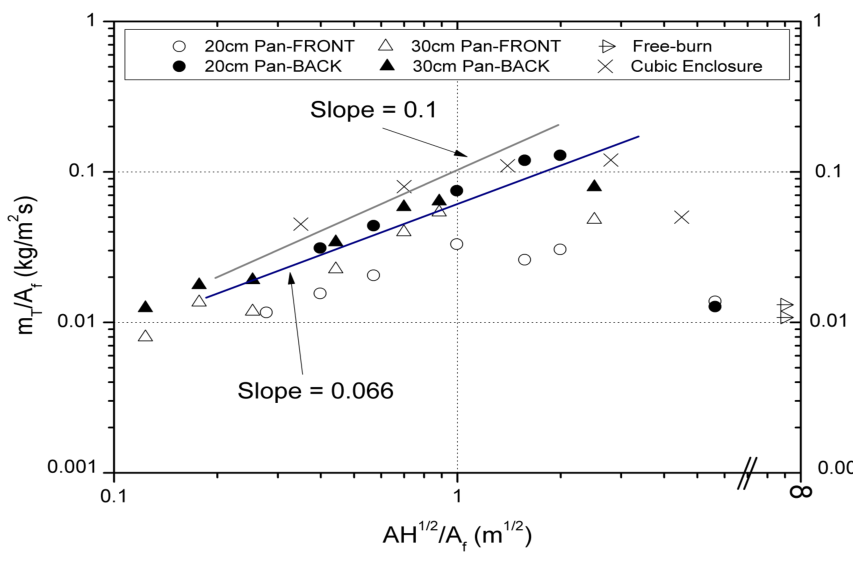

Figure 6. Mass pyrolysis rate against ventilation factor both normalized by the fuel surface

A linear fit of the data in the ventilation-controlled regime in Fig. 6 is:

$$\dot{m}_T / A_F = 0.066\ AH^{1/2}/A_F$$

Opposed to: $\dot{m}_T/A_F = 0.1AH^{1/2}/A_F$ for a cubic enclosure.

Combustion efficiency

Decrease of ventilation factor

Decrease of combustion efficiency

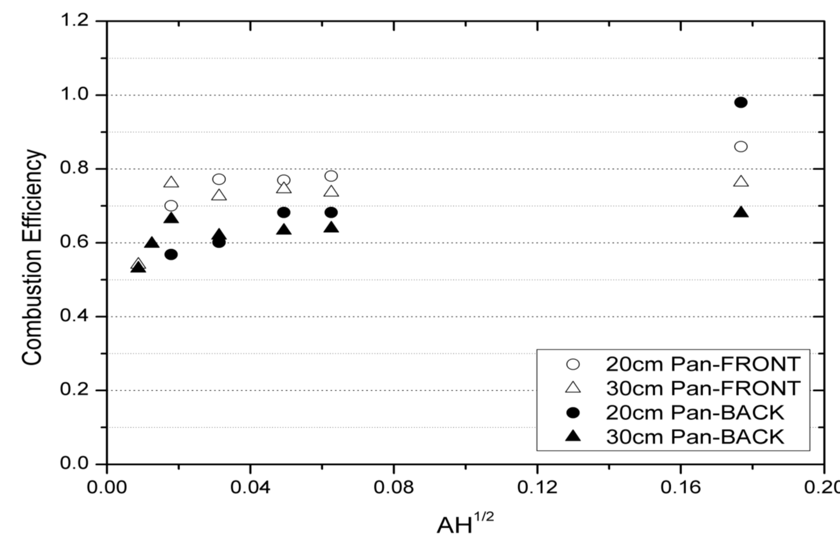

Figure 7. Combustion efficiency over ventilation factor

➢ **Location and size of pan influencing the burning behaviour**

Pool fires at rear → Formation of thick hot gas layer → Higher burning rates

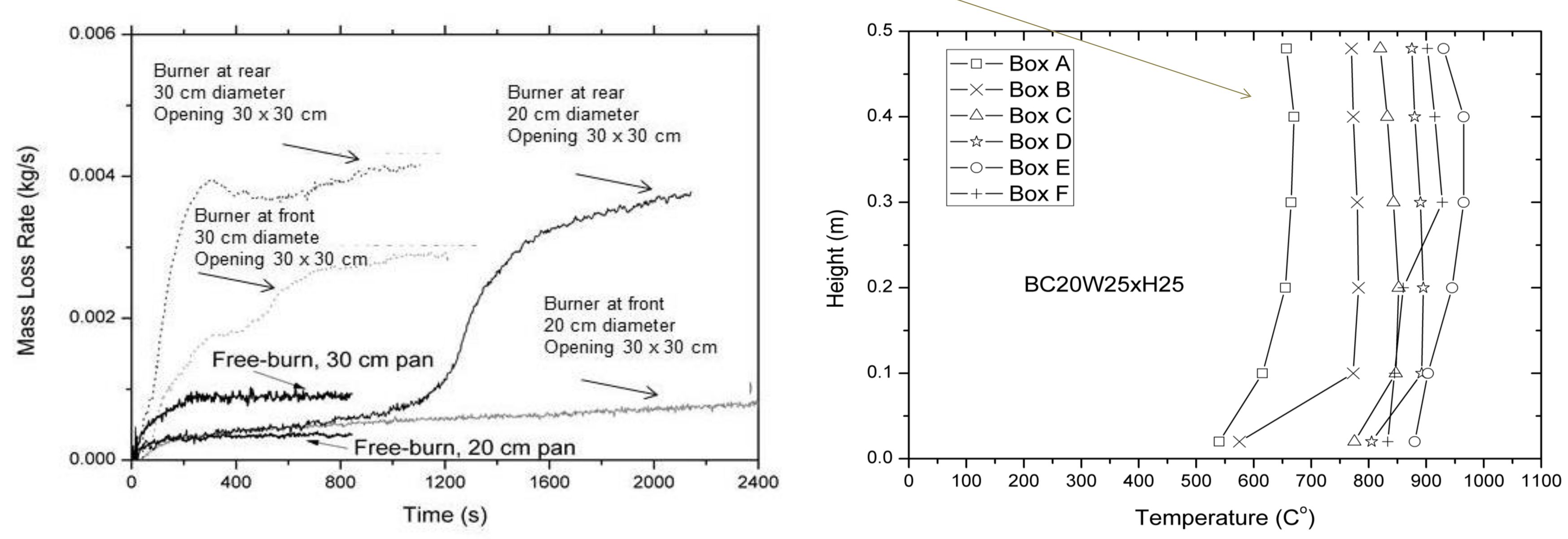

Figure 8. Comparison of mass pyrolysis rate for cases with varying fire size and location (left) and average steady-state temperature versus height for test with 20 cm pan at rear (right)

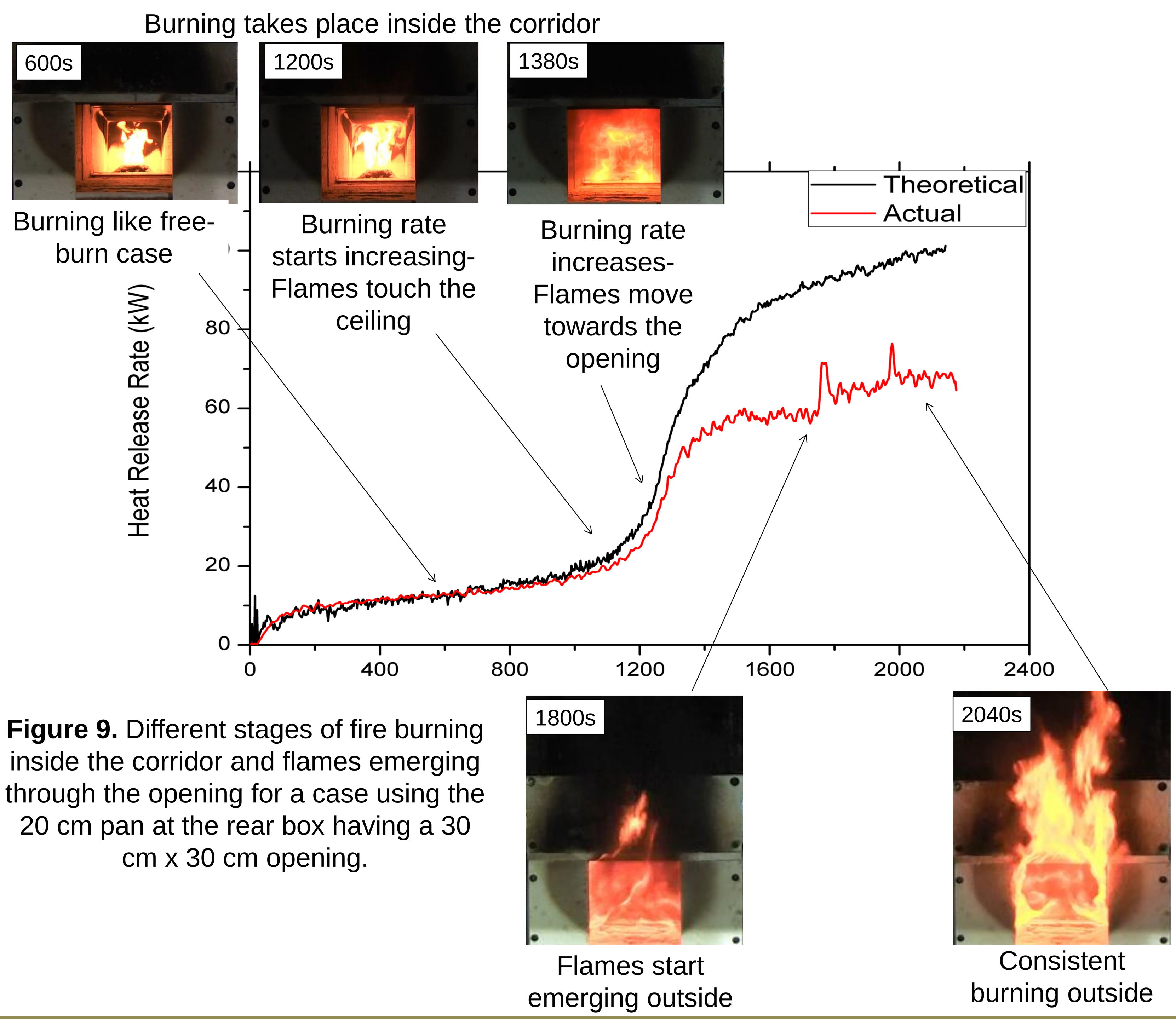

Figure 9. Different stages of fire burning inside the corridor and flames emerging through the opening for a case using the 20 cm pan at the rear box having a 30 cm x 30 cm opening.

CONCLUSIONS

The influence of three key parameters to burning behaviour of pool fires in a corridor-like enclosure was investigated, providing an extensive set of experimental data. Results show that in a corridor, burning rate is decreased by 1/3 compared to cubic enclosures with same ventilation factor. Also, a strong impact of pan location and pan size was found on the burning behaviour due to the formation of hot gas layer. Finally, decreasing the ventilation factor, the combustion efficiency decreases due to lack of oxygen availability. The present experimental data can be used for validating CFD tools.

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